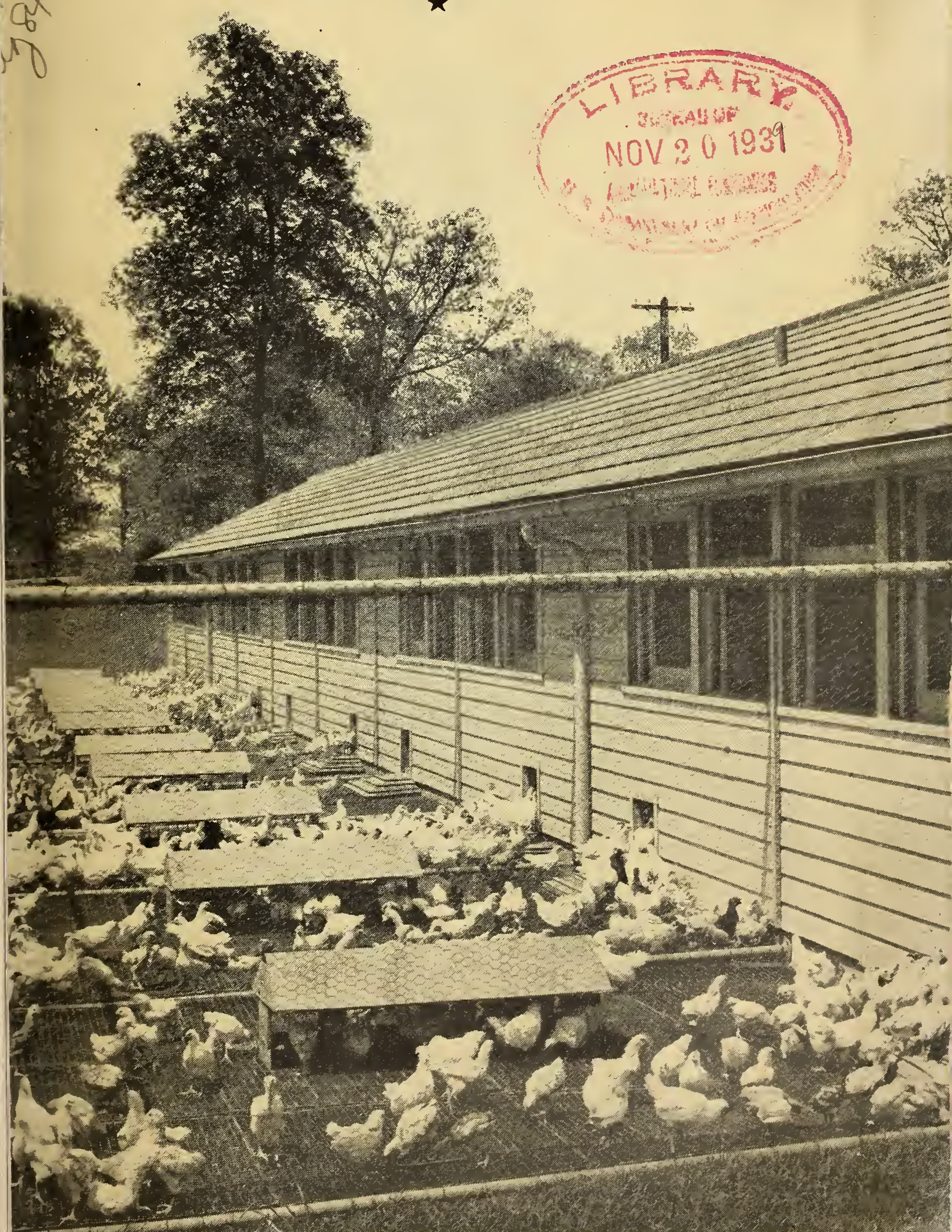
FEDERAL POULTRY RESEARCH

AT THE AGRICULTURAL RESEARCH CENTER BELTSVILLE, MD.



MISCELLANEOUS PUBLICATION No. 368
U.S. DEPARTMENT OF AGRICULTURE

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS PUBLICATION No. 368

Washington, D. C. October 1939

FEDERAL POULTRY RESEARCH

AT THE AGRICULTURAL RESEARCH CENTER, BELTSVILLE, MD.

By John R. Mohler, *Chief, Bureau of Animal Industry and Chairman of the Departmental Poultry Committee*

CONTENTS

FACILITIES AND EQUIPMENT

One of the principal experiment stations maintained by the United States Department of Agriculture is located at Beltsville, Md., about 14 miles northeast of Washington, D. C. The station is conveniently reached by Highway No. 1 (the Baltimore Boulevard). The establishment is designated the Agricultural Research Center and includes facilities for investigational work by eight of the Department's bureaus. The Bureau of Animal Industry occupies about 4,200 acres of the center and devotes 177 acres of the area to yards, buildings, and other facilities used for poultry research work.

The poultry farm has been used for experimental work for more than 25 years. In 1934, when the new laboratory buildings (fig. 1) were begun, the farm was enlarged and the poultry houses rebuilt. All the poultry houses (figs. 2 to 9) and other buildings used for poultry investigations are thus practically new. Only one of the original buildings is now standing.

The poultry farm has 4 laboratory buildings, a central heating plant, and more than 200 houses of various sizes for housing the experimental flocks and equipment. The poultry buildings have a capacity of approximately 7,000 adult chickens, 1,500 turkeys, and 200 pigeons. In addition, facilities are available for brooding 13,000 chicks and 2,500 poults during the normal brooding period from February 1 to June 1. Each year several thousand chicken and turkey eggs are hatched for experimental purposes. The seasonal capacity of the incubators (fig. 10) is about 150,000 eggs.

161046°—39——1

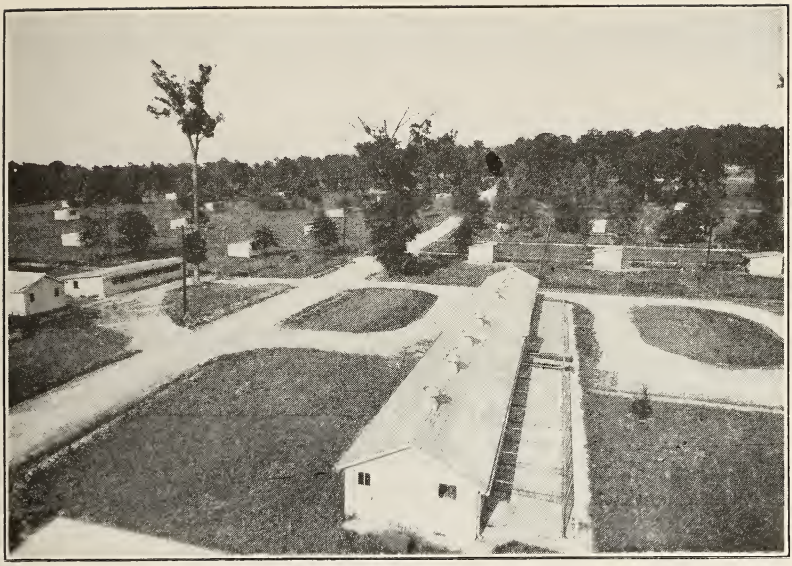
67034–B

FIGURE 1.—Laboratory buildings used for poultry experimentation and administration. The buildings from left to right are used for biology, nutrition, genetics and physiology, and fattening and cold storage.

Poultry research work is conducted by four administrative units of the Bureau at the Agricultural Research Center. These are the Animal Husbandry, Animal Nutrition, and Zoological Divisions, and the Animal Disease Station. The area occupied by the Animal Husbandry and Animal Nutrition Divisions, which is commonly known as the poultry farm, is located at the northwest corner of the research center; the part used by the Zoological Division adjoins the poultry

67036–B

FIGURE 2.—One of the large brooder houses with service quarters in the center. Each of the 10 sections in each wing is equipped with a concrete floor and a separate yard. Both interior and yards are equipped with wire-floor sections to facilitate the control of parasites and disease.



67050—B

FIGURE 3.—Brooder house (in foreground) used in conducting nutrition experiments. Each wing is divided into eight sections and the temperature of each is individually controlled. The colony houses in the left background are used for growing cockerels and those in the right background are for growing pullets.

67569—B

FIGURE 4.—Winter scene. Three laying houses used in conducting breeding investigations. Note that fronts are left open during cold weather as the climate in southern Maryland is not too severe for laying hens. Each house is divided into sections with solid partitions between the sections.

34026—C

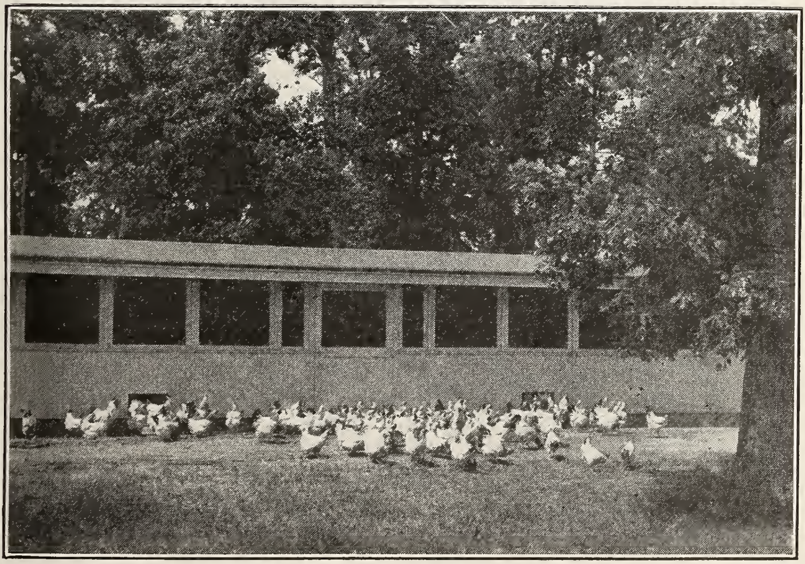
FIGURE 5.—One of the laying houses used in conducting nutrition investigations. Each wing is divided into six sections and the center part is equipped as a service room. The yards shown in front have concrete floors and the wire fencing extends over the top.

67035—B

FIGURE 6.—Colony houses for growing pullets used in breeding investigations. This group is located in a large enclosure with no separate yards for the colony houses. Note the covered feed troughs and water fountain in front of each house.

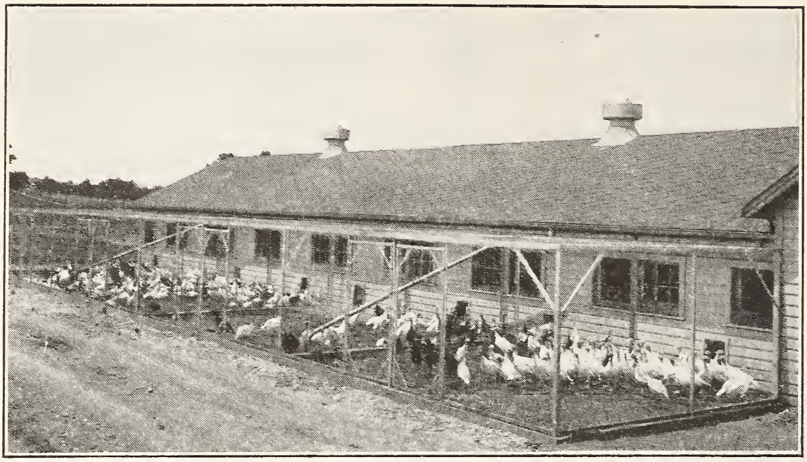
67056—B

FIGURE 7.—Pigeon loft and feed house (right foreground), carpenter shop, garage, storage shed (right background), and colony breeding houses (left).



67038—B

FIGURE 8.—A flock of Light Sussex pullets used in breeding investigations. The average egg production of this flock was increased from 129 to 177 in 4 years through the use of the progeny test. These birds are housed in one of the open-front laying houses provided with screens but no glass.



67029—B

FIGURE 9.—Brooder house for raising young turkeys in partial confinement. The pens have wire floors which greatly reduce the possibility of infestation with parasites. The wire fencing extends over the top of pens to keep out sparrows and other flying birds. Electric brooders are used in each section and the building is supplied with supplementary steam heat.

67903—B

FIGURE 10.—Sorting pedigreed hatching eggs in the incubator room. As the eggs are selected they are placed in the incubator trays with the large end up. The four trays in the right foreground are turkey eggs while those in the other four trays are chicken eggs. Note incubators (dark cabinets) in center background. They are heated and ventilated automatically. The large machine, at the extreme right, has a capacity of about 14,000 eggs.

farm on the south; and the Animal Disease Station's poultry buildings are at the southwest corner.

The main projects conducted in the first two divisions are poultry-breeding and physiology of development and reproduction investigations, supervision of the National Poultry Improvement Plan (under the direction of the Animal Husbandry Division), poultry-feeding and physiology of nutrition investigations (directed by the Animal Nutrition Division), and poultry-meat and egg-quality studies (conducted jointly by the two divisions).

Research on poultry parasites and investigations concerning the treatment of poultry for the removal of internal parasites are the principal poultry projects conducted by the Zoological Division. The poultry projects conducted at the Animal Disease Station consist of research on poultry diseases with special emphasis on fowl leukosis.

The studies on parasites and disease are chiefly of laboratory character and require but little space for yards. Most of the research projects in all divisions are planned with a view to coordinating them with similar work conducted by the various State experiment stations. Furthermore, the studies in progress in the research laboratories at Beltsville are of such fundamental nature that the results obtained have a Nation-wide application.

ADMINISTRATIVE OFFICES

The original plans for the buildings at the poultry farm called for only such equipment as was necessary for conducting research projects. At that time the administrative and clerical offices were in Washington, D. C. Later developments, however, necessitated the removal of these offices to the buildings at the research center. Aside from general superivsory administration by officials in Washington, the poultry work of the Animal Husbandry and Animal Nutrition Divisions, the Animal Disease Station, and part of the work of the Zoological Division is directed from offices at the research center.

THE NATIONAL POULTRY IMPROVEMENT PLAN

As previously mentioned, the supervision of the National Poultry Improvement Plan is a project of the Animal Husbandry Division. This project is administered from the offices at Beltsville in cooperation with the Pathological and Biochemic Divisions of the Bureau. Three poultry coordinators and one associate poultry geneticist devote full time to this plan, which is conducted in cooperation with an official State agency in each of the cooperating States. The official State agency directs, supervises, and is responsible for flock selection, testing for pullorum disease, and other local administrative work involved in the operation of the plan. The Bureau is responsible for coordinating the program among the States in which the plan is in operation.

The National Poultry Improvement Plan, which was placed in operation July 1, 1935, was developed primarily to aid the poultry industry in improving its efficiency. This is being accomplished through (1) the development of more effective State programs for improving the production and breeding qualities of poultry and reducing mortality from pullorum disease; (2) the authoritative identification of breeding stock, hatching eggs, and chicks with respect to quality, and describing them in uniform terms; and (3) the establishment of an effective cooperative program through which the best results from scientific research can be applied immediately to the improvement of poultry and poultry products.

Any poultry breeder, hatcheryman, or flock owner in any State having an official State agency may cooperate in the plan by signing an agreement with this agency and complying with the provisions of the plan. Following official certification of the quality of his flocks and hatchery products by the State agency, the flock owner, hatcheryman, or poultry breeder may use the emblem, designs, and terminology of the national plan in advertising his flock or hatchery products. Official terminology, labels, and designs indicating the breeding stages and pullorum-control classes are provided so that participating breeders and hatcherymen may appropriately identify and mark their breeding stock and hatchery products. Use of the official terminology, labels, and designs is limited to persons participating in the plan and complying with its provisions.

The plan includes five progressive breeding stages, each having successively higher requirements in the following order: (1) U. S. Approved, (2) U. S. Verified, (3) U. S. Certified, (4) U. S. Record of Performance, and (5) U. S. Register of Merit. Three progressive pullorum-control classes are provided, each with successively higher requirements as follows: (1) U. S. Pullorum-Tested, (2) U. S. Pullorum-Passed, and (3) U. S. Pullorum-Clean. Minimum requirements are established for each breeding stage and each pullorum-control class.

This plan is now (July 1939) in its fifth year of successful operation (table 1). It has been voluntarily adopted by breeders and hatcherymen in 44 States.

TABLE 1.—*Extent and nature of participation in the National Poultry Improvement Plan during the first 4 years*

Item	Participation during year ended June 30—			
	1936	1937	1938	1939
	Number	*Number*	*Number*	*Number*
States participating	34	41	42	44
Hatcheries	1,017	1,239	1,478	2,033
Hatching-egg capacity	38,066,000	52,591,786	60,623,222	75,782,922
Breeding flocks	23,813	30,558	28,820	42,591
Breeding birds	3,522,409	6,535,907	5,948,498	8,653,568
U. S. R. O. P.[1] flocks	190	352	353	[1] 396

[1] Record of performance.

The plan is resulting in reduced mortality among baby chicks from pullorum disease and in improvement in chicks with respect to potential production and breeding qualities.

RESULTS OF POULTRY RESEARCH

The Bureau keeps producers and the general public informed concerning new findings through its own publications, reports to scientific journals and poultry magazines, and press and radio announcements. The Bureau's field workers and those of the Extension Service likewise disseminate the results of research.

The following pages summarize the findings of recent years and the objectives of some of the projects now in progress.

POULTRY-BREEDING INVESTIGATIONS

In an intensive study of progeny testing (fig. 11) as a means of improving egg production, Bureau investigators have definitely established the value of this method by the performance of progeny-tested males and females having good pedigrees. One of the sires in this project has a trap-nest record of 50 daughters which averaged 201 eggs in 12 months. One of the hens has a record of 248 eggs and 11 of her daughters averaged 239 eggs in 12 months. In another experiment involving progeny testing, the egg production of the Light Sussex flock was increased from an average of 129.2 eggs in 1933 to 177.5 eggs in 1937.

Close inbreeding consisting of brother-and-sister matings for 3 successive years decreased both egg production and hatchability. Fertility, however, was not materially affected. Intercrossing of the third-year progeny of the inbred pens increased egg production, hatchability, and viability of chicks, but decreased fertility. The results indicated that such close inbreeding cannot be recommended to poultrymen as a system of breeding.

The influence of the date of hatch and the date of first egg on first-year egg production was the object of a recent statistical study. The purpose was to find adequate criteria for predicting or estimating relative egg production and to establish any linkages that may exist as indicated by the correlation coefficients. The date of hatch and the date of first egg were found to have an insignificant effect on egg production when the date of hatch is during the normal hatching season of 7 or 8 weeks' duration. That was the period covered by this study.

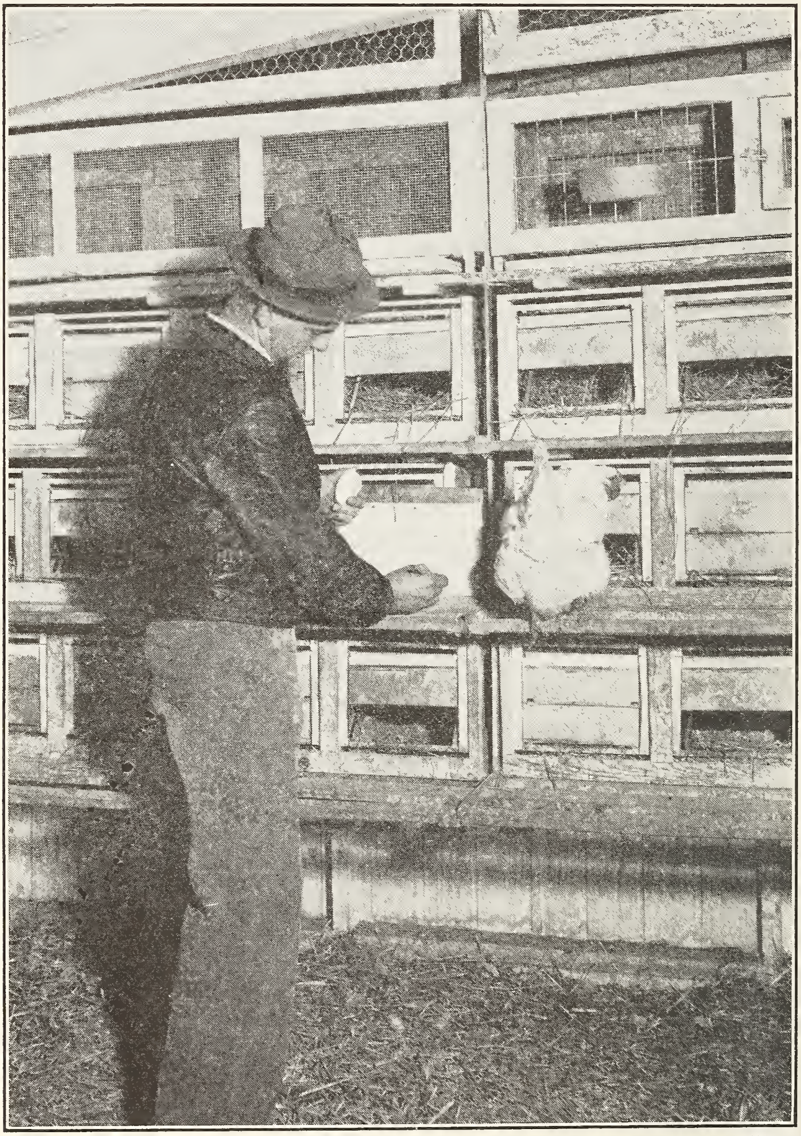
During recent years Bureau scientists have made a study of the different characters of fowls and their correlation with egg production. The results obtained thus far indicate that neither live-bird nor dressed-carcass measurements are reliable indices of egg-laying ability. There is an apparent absence of significant relationship between the length, breadth, or shape of skull and egg production. The weight of the brain bears no consistent relationship to the number, total weight, or average weight of eggs laid by a bird. Moreover, the results have failed to show any significant correlation between egg production and three bone measurements, namely, length of back, width of back from femur joint to femur joint, and length of keel. In general the evidence gave no support to the common belief that there is an egg-laying type of domestic fowl, type being considered from the standpoint of skeletal structure.

Many hereditary traits, however, are known to be indications of egg production. In this investigation the following traits were used: Sexual maturity (age at first egg), number of eggs laid the first 50 days, number of eggs laid to March 1, length of winter pause, percentage of production to March 1, number of eggs laid during

161046°—39——2

August and September of the year following date of hatch, number of eggs laid the last 50 days of the first laying year, and broodiness.

The correlation between sexual maturity and total egg production in both the Rhode Island Reds and White Leghorns was found to be highly significant even when the influence of the percentage of pro-



67736—B

FIGURE 11.—The type of trap nest and record sheets used in the progeny-testing investigations at the Agricultural Research Center. All hens used in breeding investigations are trap-nested and the weights of the eggs taken and recorded. The row of coops above the top tier of nests is used for confining broody hens or others that are to be kept away from the rest of the flock.

duction to March 1, length of winter pause, and the number of eggs laid during August and September were considered.

The number of eggs laid the first 50 days, the number of eggs to March 1, length of winter pause, and percentage of production to March 1, were all measures of the same trait, rate of production. The best of these measures was found to be the percentage of production to March 1. This measure of rate had the smallest correlation with each of the environmental factors studied and, with the exception of the number of eggs the first 50 days, with sexual maturity also.

The number of eggs laid during August and September of the year following the date of hatch and the number of eggs laid the last 50 days of the first laying year were found to be similar measures of persistence of production. The better of these two measurements was the number of eggs laid during August and September. The number of eggs laid during August and September had a much smaller correlation coefficient with each of the environmental and hereditary factors considered, except length of winter pause and percentage of production to March 1, than the number of eggs laid the last 50 days.

Broodiness was studied in the Rhode Island Red pullets only, as very little broodiness was encountered in the White Leghorns that were used. It was found that the broody hens, on an average, produced fewer eggs, matured later, laid at a slower rate, and were less persistent in production than the nonbroody hens.

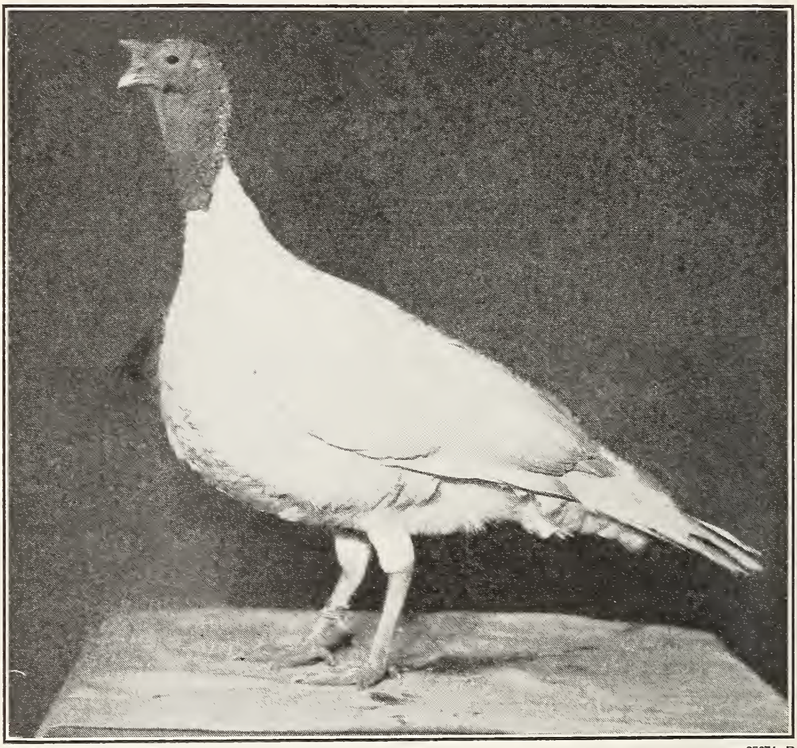
The three major hereditary traits, sexual maturity, rate as measured by percentage of production to March 1, and persistence as measured by number of eggs laid during August and September, were found to be excellent criteria for predicting first-year egg production in both breeds. When the fourth trait, broodiness, was added to these major traits, it increased the prediction value slightly in the Rhode Island Reds. Other factors that were studied, when added to the three major traits mentioned, produced no significant change in the prediction value.

No evidence of linkage was found in either breed between the best measure of rate, percentage of production to March 1, and sexual maturity, as indicated by the coefficients. There was no significant correlation between any of these factors and first-year egg production in the White Leghorns and Rhode Islands Reds. The correlation between the better measure of persistence and the number of eggs laid during August and September and sexual maturity was small for the White Leghorns and Rhode Islands Reds, indicating that there was comparatively little significance or linkage between these factors.

A study was made of the inheritance of sexual maturity and rate of egg production. This work revealed that these characteristics were hereditary because full sisters were less variable than more distantly related birds.

Among the experimental flocks at Beltsville the investigators found a new splashed-white chicken, a mutation from the Rhode Island Red. This mutation may best be described as a red-splashed white and is recessive to the full expression of color in the Rhode Island Red.

In regard to plumage structure, it has been shown that hen-feathering is dominant to cock-feathering and inherited on a monohybrid basis, although it appeared that modifying genes were involved. The presence of vulture hock, a characteristic of certain standard breeds has been shown to be recessive to absence of vulture hock. In a study of the inheritance of hen-feathering in Brown Leghorns, several individuals appeared with decidedly crooked necks. This crooked-neck condition was shown to be inherited and due to a single pair of recessive autosomal genes.



65674—B

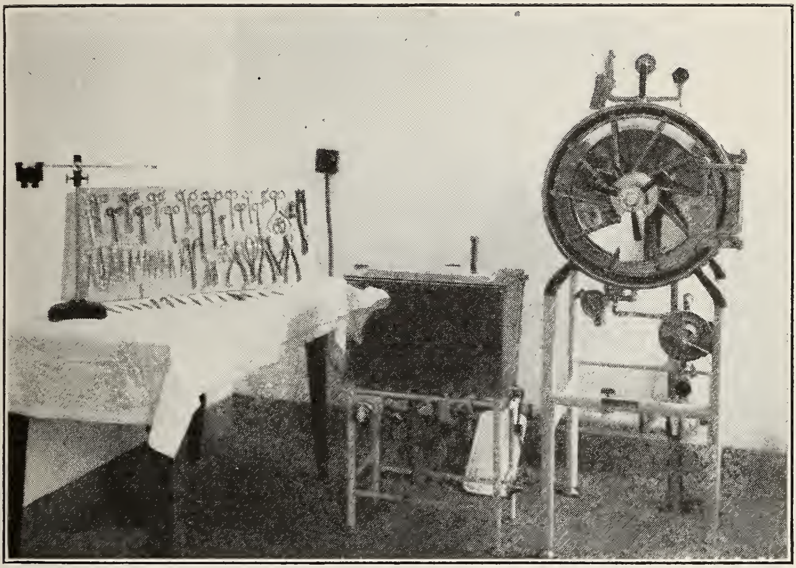
FIGURE 12.—One of the small-type turkeys that is being developed to meet the demand for a bird suitable for small ovens and small families. Note depth of body, short neck, and lack of general ranginess commonly observed in market turkeys. Several years more will be required to fix the type and otherwise complete the investigation.

In addition to the results mentioned, the scientists engaged in poultry-breeding investigations are endeavoring to produce a superior commercial strain of golden-barred Leghorns.

During recent years the development of a small type of turkey (fig. 12) has been in progress at the research center. This type is being developed for such characteristics as small size (young toms 13 to 17 pounds and young hens 8 to 11 pounds, live weight at market age), short legs with compact body, long keel with an abundance of breast meat, early maturity, and white feathers. That these characteristics are becoming fixed is shown by the larger proportion of birds which meet the desired requirements at market age. The importance of this investigation is emphasized by the current differential in price of ½ to 4 cents a pound in favor of this type of turkey.

PHYSIOLOGY OF DEVELOPMENT AND REPRODUCTION INVESTIGATIONS

Two basic problems in the physiology of poultry, that have been the subject of varied investigations at Beltsville for many years, are the physiology of development of the embryo, including hatchability studies, and the physiology of reproduction in domestic fowl. The earlier work was directed mainly toward analysis of factors influencing hatchability and study of the physics of incubation, with emphasis on the latter. In recent years it has become increasingly



67049-B

FIGURE 13.—The surgery in the Genetics and Physiology Building. The instruments, which are shown mounted for display, are sterilized before use in the steam sterilizer (center). The autoclave (right) is used for sterilizing under high pressure.

clear that the solution of many practical problems of development and reproduction must come through technical studies of fundamental physiology. Thus investigations involving the mechanism of hormone controls in the reproductive processes and study of the physicochemistry of the egg have come to occupy their place beside investigations with immediate practical ends in view.

Facilities for physiological investigations include well-equipped general laboratories, extensive modern equipment for the study of incubation and hatchability, brooders for chicks, batteries for adult birds, surgical equipment for performing operations and for post-mortem examinations (fig. 13) and special physiological apparatus.

The material available for physiological investigations is unique in several respects. Birds of several breeds and crosses are available; and lines differing genetically in one or another important respect as, for example, broodiness, egg production, and weight of eggs, provide experimental material of exceptional value. Many investigations on hatchability and incubation requiring large numbers of observations could not have been carried through on an adequate basis except in connection with the extensive breeding operations regularly in progress at Beltsville.

Investigations of hatchability and fertility at Beltsville have shown that crossing chickens of pure breeds is likely to increase or decrease hatchability over that characteristic of parental stock in inverse proportion to the original hatchability. Crossing breeds with a hatchability above 80 percent lowered hatchability about as often as it increased it among the Beltsville flocks. Crossing breeds is likely to decrease mortality of embryos during the third week of incubation but is not likely to lower their mortality during the first week.

Inbreeding is likely to increase mortality of embryos during the first week of incubation and to increase very greatly mortality during the third week. Mating first-generation females from crosses between pure breeds to males of an unrelated breed is likely to increase hatchability above that of the cross between the pure breeds because of improved egg quality of the first-generation females.

There was some indication of the presence of lethal genes which were hereditary and consequently deleterious to egg quality in the birds studied.

The inheritance of hatchability must be determined by a very large number of genes, because (1) three lethal genes have already been positively identified; (2) crosses between breeds, both of which have low hatchability, improve hatchability; (3) some factors affecting egg quality probably affect hatchability; and (4) inbreeding of itself, in some cases, appears to decrease hatchability.

In another experiment five cases of hatching eggs were packed for shipment, some rigidly and others loosely. These experimental packs were then shipped by express in two lots, one traveling 1,800 miles, the other 2,400 miles. The results showed that the eggs packed rigidly in the ordinary filler and flats, each egg being wrapped in newspaper, and also eggs in the prong-type filler stood shipments better than those packed in the ordinary filler and flat. It was also ascertained that eggs packed in rigid packs had better hatchability than eggs shipped in a loose pack, namely, the ordinary filler and flat.

The results of another experiment showed that fertility of both white- and brown-shelled eggs can be detected by candling earlier in the incubation period than is customary among commercial hatcherymen. The most practical time of early candling is between 16 and 20 hours after the beginning of incubation when eggs are incubated at 100° F. and at 30 hours if eggs are incubated at 90°. The percentages of hatch of fertile eggs incubated at these temperatures were 77.6 and 78.0, respectively. An ordinary commercial egg-candling machine equipped with a 75-watt daylight bulb was used, the operator wearing two pairs of glasses, one yellow and one blue (fig. 14). These colors produced a green effect. This equipment aided in detecting fertile eggs early in incubation.

Studies have been made on the shape and weight of eggs in relation to sex of the chicks and to their hatchability. These studies showed that egg shape did not affect hatchability, also that neither the shape nor the weight of an egg was a reliable index of sex of chicks. However, there was a high correlation between the size of chick and the size of the egg from which it was hatched.

34681—C

FIGURE 14.—Candling hens' eggs after 14 to 20 hours of incubation to determine fertility. The procedure involves the use of two pairs of eyeglasses, one pair yellow and the other blue, which make the embryo visible.

Extensive investigations have been conducted on the causes of embryonic mortality, particularly during the last 3 days of incubation. A large proportion of the mortality during this period, the investigation showed, was due to malposition of the embryo within the shell. These studies led to the development of a tray so constructed that the eggs were turned mechanically every 15 minutes, in the same manner they are turned by the setting hen. Incubation in this tray greatly reduced the incidence of certain types of malposition and increased the hatch of fertile eggs by approximately 10 percent.

A new nutritional disease causing death of many chick embryos during the third week of incubation was determined during the course of hatchability studies. The abnormal embryos most frequently appeared in eggs laid by hens receiving diets lacking in some factor or factors present in whey, liver, and wheat germ. The effective utilization of this factor or these factors was augmented by providing the birds with access to direct sunlight and green feed on range. It was later shown that direct sunlight provides the laying hen with factors, other than vitamin D, beneficial to the production of hatchable eggs, independently of the specific nutritional disease just mentioned.

A new lethal character, "stickiness," was also discovered in connection with studies on hatchability. This character, which derives its name from a sticky condition of the embryo, was identified as a simple recessive, and is lethal in homozygous conditions. The effect of the factor is manifest in extreme softness of the bones, a condition that prevents hatching.

An outstanding contribution to fundamental knowledge of egg quality was the demonstration, for the first time at Beltsville, that the mucin content of egg white determined the relative quantities of thick and thin white. On the basis of this finding, studies are now in progress to determine (1) the effects of variation in mucin content on the development of the embryo, and (2) the physiological characteristics of the oviduct responsible for deposition of thick or thin white.

Investigations have been in progress for several years on the effects of ionized air on physiological processes of the domestic fowl. This work has covered a wide field, including treatment of embryos, chicks, growing birds, and adult laying hens. Results obtained have been consistently negative, but it has been thought worth while to subject this problem to further investigation in view of the varied and apparently exaggerated claims appearing in the literature.

Experiments in artificial insemination of chickens and turkeys have resulted in a practicable technique for obtaining semen from male fowl and for inseminating females. The method has already been used at Beltsville to obtain fertility in matings where a wide difference in body size between mates is a factor in lowering fertility. Artificial insemination has also been of practical value in fertilizing the eggs produced by hens in batteries and is used continuously in nutrition investigations where the hatchability of eggs produced by hens in batteries is being studied. Suitable dosages have been determined for use in inseminating hens kept in batteries. Seventy hens per week may be inseminated by the semen of a single male, which produces on the average 1.0 cc. of semen daily, the dosage per individual hen being 0.1 cc. once each week. Smaller doses have also given good fertility and may be used when it is desired to obtain the maximum number of chicks from a single male. Breeders have been interested in learning the technique for artificial insemination in order to extend the usefulness of valuable males. During 1938 two investigators used the artificial insemination technique to effect intergeneric crosses, one cross being between the guinea fowl and chickens, another between the chicken and pheasant. The method has also proved useful in various experimental procedures and in researches involving the oviduct.

The rapid development of knowledge of endocrines or hormones has opened new and little-investigated possibilities in the control of physiological functions, particularly reproduction. Research activities in this field are being broadened.

It is well known that broodiness in laying hens interferes with egg production. Studies on the physiology of broodiness have shown that the pituitary glands of genetically broody laying hens contain much more prolactin, a chemical substance believed to induce broodiness, than do the pituitaries of genetically nonbroody hens. The part played by certain environmental conditions in stimulating or in suppressing broody behavior in laying hens is also being studied.

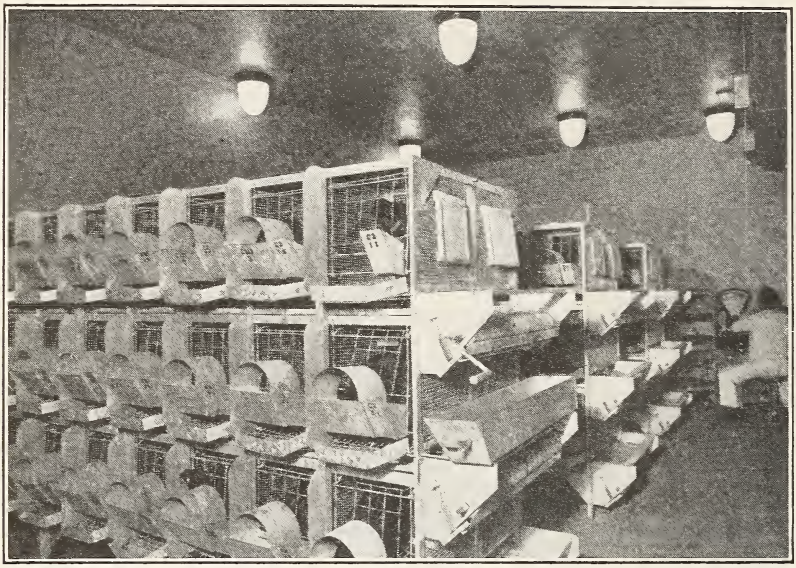
The various rhythms of egg production are almost certainly controlled by rhythms in the concentration or balance of endocrines (or hormones) in the blood stream. The problem of first importance here is ovulation, that is, the mechanism which causes shedding of the ripened yolk. Experiments at Beltsville have confirmed the work of others in demonstrating that hormones contained in the serum of pregnant mares will cause the simultaneous development and growth of many yolks. Investigations are at present under way to reduce this effect to strictly quantitative terms, to determine the specific hormone or hormones responsible for yolk growth, and, finally, to determine what hormones or specific balance of hormones will cause ovulation of either the ripened or the immature yolk.

POULTRY NUTRITION AND PHYSIOLOGY OF NUTRITION STUDIES

Investigations in poultry nutrition and physiology of nutrition conducted during the last few years include studies of feed requirements for growth, maintenance, and egg production (fig. 15); heat production and gaseous metabolism; protein, mineral, and vitamin requirements (fig. 16); the effect of nutrition on reproduction; nutritional-deficiency diseases; the physical and chemical composition of poultry meat and eggs; and the function of the gizzard.

Studies of the effect of nutrition on growth of chicks demonstrated that the relationship between live weight and feed consumption is expressible with a high degree of accuracy by the equation of the curve of diminishing increment. The studies showed also that the relationship between efficiency of feed utilization and live weight is expressible with essentially the same degree of accuracy by a straight-line equation. Also, it was found that full-fed chickens use their feed less efficiently for growth than chickens receiving lesser quantities. The most efficient use of feed for growth was made by chickens that received only 50 to 70 percent as much feed as full-fed chickens. However, the most efficient level of feed intake from the standpoint of physiology may not be the most economical level of feed intake.

The quantity of feed required for maintenance by both laying and nonlaying chickens of different live weights was determined. Leghorn chickens having an average live weight of 1,700 grams (about 3¾ pounds) were found to have a maintenance requirement of about 66 grams (about 2⅓ ounces) of feed a day. The additional quantity of feed required for the production of an egg was found to be 40.27 ± 5.15 grams (about 1.42 ± 0.18 ounces) above the maintenance requirement.



67044—B

FIGURE 15.—Air-conditioned room equipped with batteries for laying hens. Both the temperature and humidity can be held constant. The batteries are used for nutrition experiments.

67047—B

FIGURE 16.—Special battery-brooder room with individual compartments, used in conducting nutrition experiments in which a feed-consumption record of each chick is desired.

The heat and gaseous metabolism of growing chicks from hatching to the age of 18 weeks was measured. With the aid of these measurements it was possible to demonstrate for the first time the course of the diurnal rhythm of energy metabolism in the domestic fowl. The data obtained on oxygen consumption, heat and carbon dioxide production, and water elimination are of considerable practical value in designing ventilation systems for poultry houses in which large numbers of chickens are to be kept in batteries or cages.

In studies of the protein requirement of growing chickens (fig. 17) it was found that growing chicks made the greatest gain per pound of feed when their diet contains about 21 percent of protein. According to the data obtained, a diet that contains 20 percent of protein is about 99.7 percent as efficient as one that contains 21 percent; a diet

67051-B

FIGURE 17.—A section of the general laboratory in which feedstuffs used in nutrition experiments are analyzed.

that contains 19 percent is 98.7 percent as efficient; and diets that contain 18 and 17 percent are 97.2 and 94.6 percent, respectively, as efficient. The efficiency of diets of lower protein content was found to decrease very rapidly as the protein content decreased. As the protein content was increased above 21 percent the efficiency of the diets decreased somewhat more rapidly than when it was decreased below 21 percent. When the cost of diets of different protein content is known it is possible to calculate with the aid of the data obtained in these studies which diet is the most economical.

An investigation of the calcium and phosphorus requirements of laying chickens led to the finding that a marked excess of calcium in the diet has a harmful effect on hatchability.

Studies of the vitamin requirements of laying chickens disclosed that a deficiency of vitamin E in the diet tends to manifest itself by a significant increase in first-week embryonic mortality. These studies also demonstrated that only a very small quantity, if any, of vitamin B_1 is required for hatchability. In addition many of the findings of others about the vitamin requirements for egg production and hatchability were verified.

In a study of the functions of the gizzard, this organ was removed surgically from a number of fowls (fig. 18). One lived for as long as

54330—B

FIGURE 18.—A Rhode Island Red cock that lived for 4 years after the removal of its gizzard. The operation was performed to determine the effect of the loss of the gizzard on the fowl's digestion.

4 years after the operation, thus demonstrating that the gizzard is not an essential organ.

Among the other studies which have yielded significant and valuable information are the following: (1) The normal development of the leg bones of chickens; (2) the comparative value of scabbed barley, normal barley, and yellow corn in diets for laying chickens; (3) the effect of grinding on the digestibility of flint corn; (4) the influence of previous feeding on the nitrogen excretion of fasting chickens; (5) the energy and gaseous metabolism of deutectomized [1] and intact day-old chicks; (6) a comparison of digestibility in gizzardectomized [2] and normal chickens; (7) the effect of grit on digestibility; (8) the loss of weight of chicken eggs during incubation; (9) alfalfa-leaf meal as a source of vitamin A; and (10) the effect of light, and of soybeans and other supplements on seasonal hatchability and egg production.

Current work in poultry nutrition includes studies of (1) the protein requirements for egg production; (2) the value of different pasture grasses (fig. 19); (3) miscellaneous studies of chick nutrition;

67040—B

FIGURE 19.—Colony houses for laying hens. Sixteen houses are in this group. Each has two separate pasture plots planted to the same kind of grass. Four different grasses, each in quadruplicate sets, are being studied. The purpose of this investigation is to compare the relative value of different grasses for laying hens receiving the same basal diet.

(4) the effect of different feedstuffs and combinations of feedstuffs on the flavor and desirability of turkey meat; and (5) an intensive study of gizzard erosion.

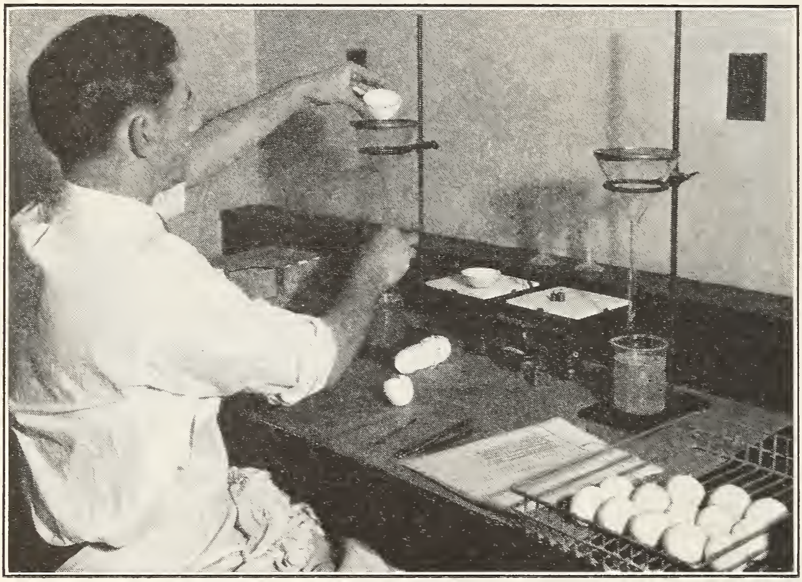
POULTRY-MEAT AND EGG-QUALITY INVESTIGATIONS

In a study of the composition of the chicken, before and after fattening, it was found, contrary to common belief, that a part of the water in the tissues of chickens is not replaced by fat during the process of fattening but that the absolute quantities of both the water and fat are increased. It was also observed that there is a tendency for the percentage of breast and leg muscle to be greater in chickens reared on range than in those reared in confinement.

[1] Signifies surgical removal of the yolk.
[2] Signifies surgical removal of the gizzard.

When chickens were fattened, or finished for market, at different ages, it was observed that the absolute gain in live weight made during the finishing period increased with age up to about 20 weeks, but that the relative gain decreased. The feed records showed that in general the feed required per unit gain increased with age. The percentage of breast and leg muscle decreased with fattening, and there was a decrease in the percentage of protein, ash, and water in the leg muscle but not in the breast muscle.

In an investigation of the effect of different feedstuffs and other materials on the color of the yolks of eggs, the feeding of graded percentages of yellow corn had essentially the same effect on the hue, brilliance, and chroma of the yolk color as the feeding of graded



67906—B

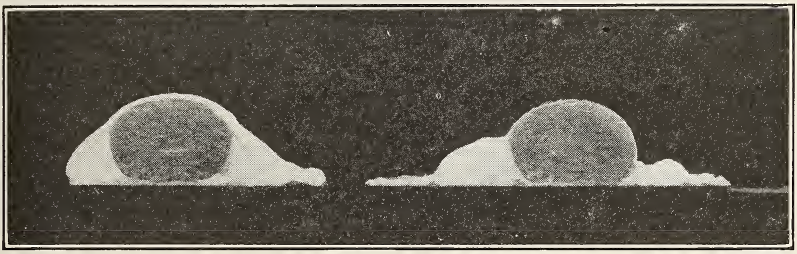
Figure 20.—Conducting research on egg quality. The thin albumen is being separated from the thick and the percentages are determined by weighing each portion. The thin albumen passes through the screen at the top of the funnel whereas the thick is retained.

quantities of pure leaf xanthophyll. Somewhat contrary to expectation, the feeding of charcoal, bone char, activated charcoal, and Lloyd's reagent had no appreciable effect on yolk color.

In one investigation of egg quality two definite lines of chickens were established in respect to the amount of thick albumen their eggs contain (figs. 20 and 21). The foundation stock of Rhode Island Reds from which these two lines originated produced eggs with an average of approximately 50 percent of thick white. By selection and progeny testing there have been developed from this original stock two inbred families that produce eggs averaging 68 and 45 percent, respectively, of thick white to total white. These two lines are being crossed in an effort to determine the inheritance of the factors related to this character.

The rate of deterioration of eggs has been studied for five lines of White Leghorn pullets. Although there were no significant differences when fresh, the eggs laid by the five lines differed materially after they were held for 3 weeks without refrigeration. Fresh eggs from two lines had exactly the same mean percentage of thick white but after these eggs were held for 21 days at approximately 78° F., the mean percentage of thick white for one of the lines was 32 and for the other 13. The results from eggs laid by 132 pullets showed no correlation between the percentage of thick white in fresh and stored eggs. This work showed also that rate of deterioration of thick white is dependent on hereditary factors as well as storage conditions.

A statistical analysis of available data has revealed that a fairly accurate prediction can be made of a pullet's future egg weight from a knowledge of the average egg weight of the first eggs laid, body weight, and age at first egg.



67907—B

Figure 21.—Vertical cross sections of two poached eggs illustrating a large percentage of thick albumen (left) and a small percentage (right). Note the thickness of albumen covering the yolk at left as well as the even distribution and greater quantity. The eggs are from two lines of Rhode Island Reds which have been developed in breeding investigations. One line was bred for a large percentage of thick albumen and the other for a small percentage. The eggs illustrated are typical of the results obtained.

POULTRY-PARASITE INVESTIGATIONS

Poultry-parasite investigations constitute one of the six major projects of the Zoological Division. The scientists assigned to this project devote their entire time to investigations concerning the life histories of parasites, effect of parasitism on the health of birds, and the control and treatment of poultry parasites.

Approximately 6 acres of land have been set aside for these investigations. The site is located at a considerable distance from land used for other poultry investigations, thereby providing isolation. This arrangement is highly desirable since some diseases of poultry are transmitted by flying insects and other winged arthropods that serve as intermediate hosts. The main laboratory building (fig. 22) and the building devoted exclusively to investigations on coccidiosis of poultry (fig. 23) were completed in the fall of 1934 and occupy separate corners of areas used for poultry-parasite investigations. The insectary (fig. 24) is a recent addition to the facilities and is being used for the rearing of insects and other arthropods used in the experiments. Each building is adequately equipped for the purpose for which it is intended. A large number of outside pens (fig. 25) also are used during the warmer months of the year. There are deep ditches around each pen to prevent seepage from one pen to another. Double fences prevent the birds in any pen coming in contact with those of other pens.

71141—B

FIGURE 22.—The poultry-parasite laboratory building where life-history studies of poultry parasites are conducted under the direction of the Zoological Division.

71143—B

FIGURE 23.—The coccidiosis building on the Zoological Division's section of the poultry farm. This building serves as an isolation unit for all experimental work with coccidiosis of poultry. The incinerator shown at right is connected with the main building by means of chutes and is used for burning all litter and other material from the experimental pens.

71142—B

Figure 24.—The insectary (left) used in rearing insects and other arthropods needed in conducting life-history investigations of poultry parasites.

71087—B

Figure 25.—Experimental pens for fowls used in parasite investigations. The wire fencing is stretched on steel posts set in concrete. A 5-foot lane is provided between the pens to keep the birds of the different pens from having any contact through the fence. The semiopen shelters are equipped with wire floors to prevent the birds from having access to droppings.

The experimental work on coccidiosis has been confined chiefly to the control of this disease by diet and checking the symptoms by tonic treatment. In a number of tests, chicks were supplied, for about 1 week, with drinking water containing traces of iron sulfate and copper sulfate. The birds were then infected with öocysts that produce the cecal type of coccidiosis and the treatment continued about 2 or 3 weeks longer. The treated birds gained more weight and eliminated significantly smaller numbers of öocysts than the untreated controls. Moreover, the treated chicks had fewer hemorrhages than the untreated controls. Practically similar results were obtained when chicks were exposed to natural infection by being placed on ground known to be contaminated with coccidia. Better results were obtained when the tonic was available to the chickens for about a week before these birds were exposed to infection than when the infection took place before the tonic was used.

Experimental data show that chickens infected with tapeworms at from 2 to 4 weeks old gain less weight than noninfected chicks of the same age. The infected birds also eat less feed and drink less water.

Tapeworms require insects and other arthropods as intermediate hosts for their transmission from one bird host to another. Therefore, the control of these parasites is closely linked with a thorough knowledge of the bionomics of the intermediate hosts.

New intermediate hosts of poultry tapeworms are constantly being found and the present list includes such various arthropods as beetles, flies, earthworms, slugs, snails, and grasshoppers. Recently, ants were incriminated as intermediate hosts for two of the largest and most important tapeworms of poultry.

In studies on gapeworms of poultry, both turkeys and guinea fowls were found to be susceptible to infection throughout life, whereas chickens were susceptible to infection only during the first few weeks of life. Guinea fowls, however, do not develop symptoms typical of gapeworm infestation in chickens. Attempts to infect adult domestic pigeons and ducks with gapeworms were unsuccessful.

Experiments have showed that young turkeys developed gapeworm symptoms and began dying from gapeworm disease earlier than chicks. The number of pairs of worms developing and ultimately reaching the tracheas was proportionately greater in young turkeys than in young chickens. The inflammatory reaction in the tracheas of young turkeys was also much more severe than in chickens.

Barium antimonyl tartrate, used as a dust, has been found to be a very effective remedy for the removal of gapeworms from the tracheas of chickens and young turkeys. The birds to be treated are confined in a metal box and the drug is applied by means of a dust gun. This procedure resulted in the inhalation by the birds of the powdered antimonyl tartrate which removed, on an average, 95 percent of the gapeworms from the tracheas.

In addition to the investigations mentioned, the Zoological Division cooperates with the Food and Drug Administration in testing drugs and remedies that are offered for sale or advocated for use in the treatment of parasitic diseases of poultry. A part of this section of the research center is devoted to the treatment of parasitized fowls with drugs that are to be tested (fig. 26). The fowls are then kept under close observation so that the effect of the drugs may be studied.

POULTRY-DISEASE INVESTIGATIONS

The Animal Disease Station of the Bureau occupies quarters at the research center that are widely separated from the other units men-

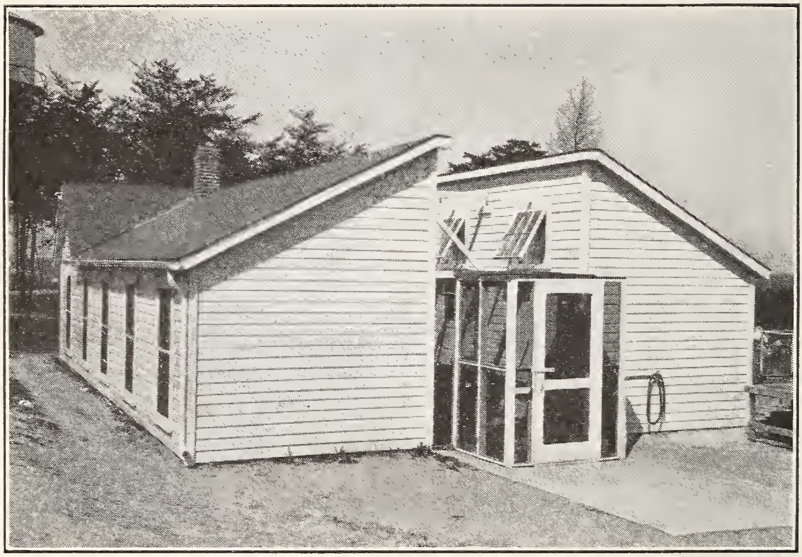
564—C

FIGURE 26.—Administering an anthelmintic to a fowl at the zoological laboratory. Veterinary preparations of various kinds are tested by actual dosage of fowls known to be effected with certain parasites. Investigations of this kind are conducted cooperatively by the Bureau of Animal Industry and the Food and Drug Administration.

tioned. This is necessary in view of the infectious nature of many of the diseases studied. In addition, rigid sanitary precautions are observed at the disease station. Visitors are requested to report first at the central office so that necessary care may be taken in connection with their inspection of the premises and the work conducted. The facilities and land devoted to investigations of poultry diseases comprise about 6 acres, in addition to the area used for parasite studies previously described.

The principal diseases of poultry that are the subject of investigation at the Animal Disease Station are fowl leukosis, avian encephalomyelitis, and avian tuberculosis.

The work on fowl leukosis consists principally of studies on artificial modes of transmission and the development of a transmitting agent of uniform potency. Some investigation is also being made of spontaneous incidence of leukosis, genetic transmission of leukosis through the egg, and the nature and source of the transmitting agent.

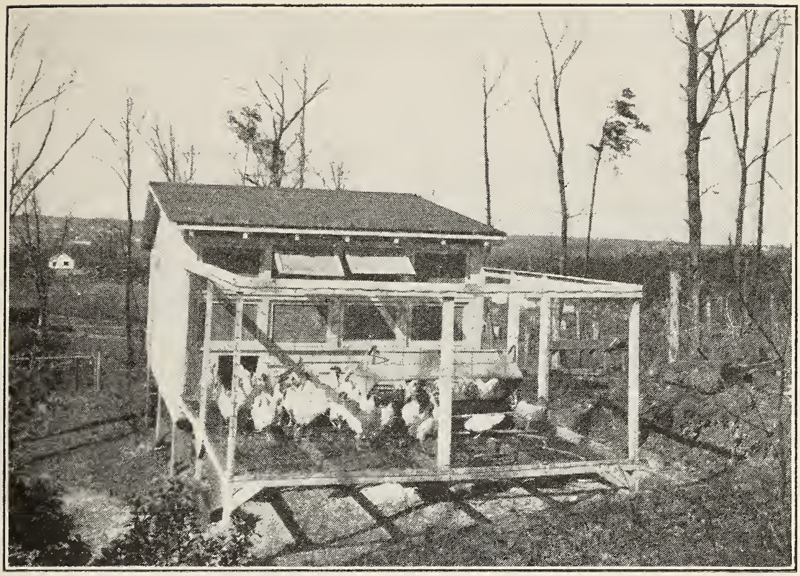


71152—B

FIGURE 27.—Brooder house at the Animal Disease Station, used in the study of the transmissibility of fowl leukosis. This building has identical compartments and equipment in each of the two sections to allow for study of diseased birds in the section at the left and for the control birds in that at the right.

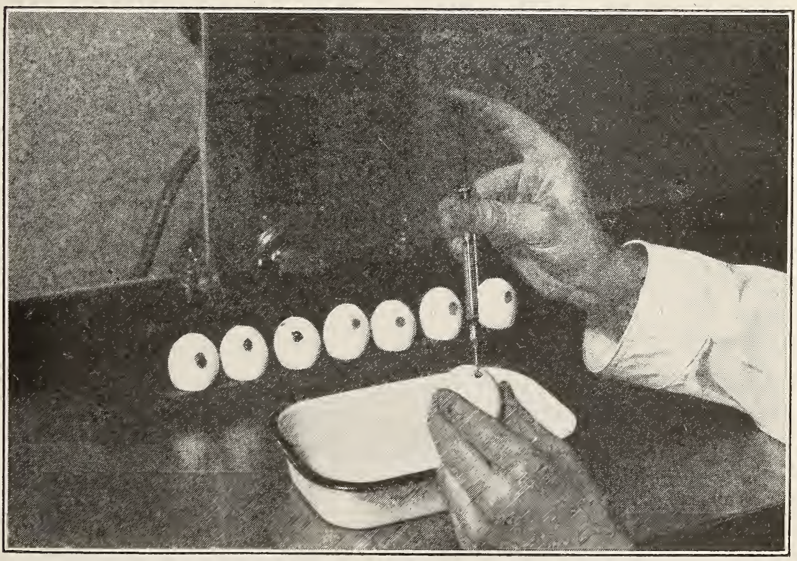
Four experiments have been conducted in the artificial transmission of leukosis (figs. 27 and 28) involving the use of 1,148 chickens, of which 560 were inoculated and 588 were uninoculated controls. Chicks for inoculation were hatched from eggs obtained from two flocks, in neither of which had leukosis been observed. Most chicks were inoculated during the first week of life. The inoculum was prepared from organs and tissues from birds suffering with leukosis, including liver, nerves, brain, marrow, ovaries, spleens, lungs, testicles, and blood. In the first experiments the same organs from 2 or 3 birds were pooled to make a composite inoculum, while in the later experiments organs from 1 bird only were used.

The disease was found to be transmissible by inoculation with suspensions of material obtained from birds affected with the disease.



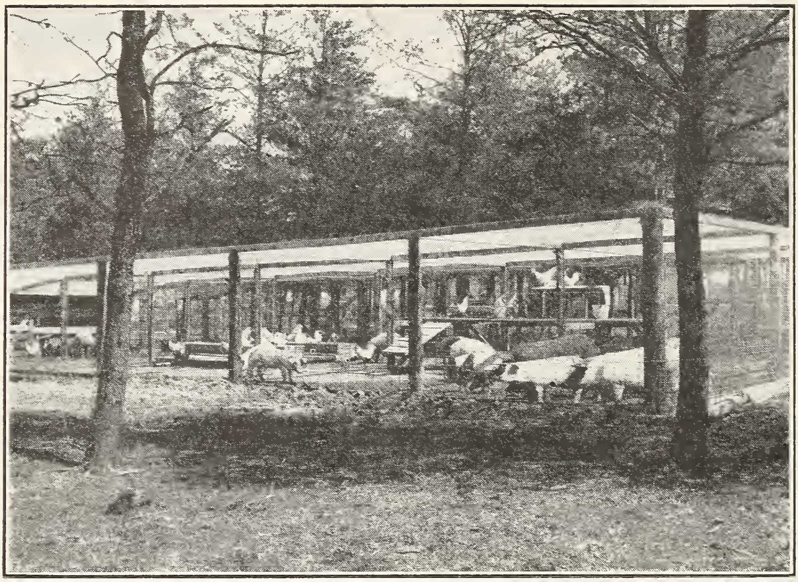
71148–B

FIGURE 28.—Isolation unit or colony house used in the study of fowl leukosis. As a disease-control measure, each unit is in the center of a large yard in which no poultry or livestock are allowed.



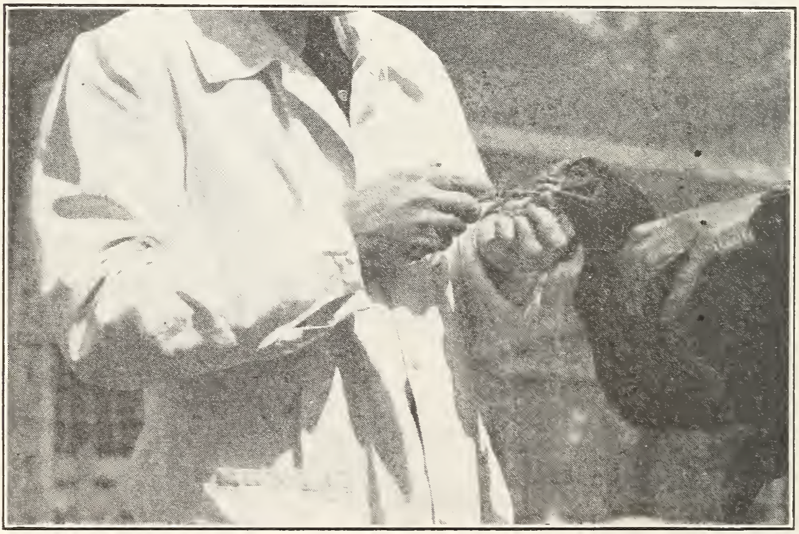
71144–B

FIGURE 29.—Inoculation of chick embryos in the study of virus diseases of poultry. A small hole is drilled through the shell to admit the syringe needle, after which the opening is sealed with wax.



8996–A

FIGURE 30.—Swine and poultry kept in same pen in an experiment designed to study the transmissibility of avian tuberculosis from poultry to swine. Although the pen is arranged so that the chickens may be fed from equipment that is out of reach of the hogs, the birds have access to the hog feeders on the ground. The top is covered with wire mesh to prevent the chickens from flying out.



71145–B

FIGURE 31.—Applying the tuberculin test to a fowl in the diagnosis of avian tuberculosis.

It was found also that both neural and visceral leukosis were caused by the same agent, but bacteriological studies showed that no microorganisms were recovered from leukotic fowls. The incubation period of artificially induced cases of fowl leukosis varied from 60 to 100 days whereas the course of the disease averaged 14 days. One of the major obstacles in conducting these studies was the development of spontaneous leukosis in the control groups.

Avian encephalomyelitis is being studied from the standpoint of its relationship to similar viruses in mammals. The virus is being propagated in chick embryos (fig. 29) and in baby chicks.

The chief purpose of the work with avian tuberculosis is to obtain more complete information concerning the transmissibility of the disease organism from poultry to swine (figs. 30 and 31).

TESTING BIOLOGICAL PRODUCTS

In addition to the various research projects mentioned, the Bureau has facilities for making tests of poultry-biological products when conditions warrant. These products include fowl pox vaccine, pigeon pox vaccine, and laryngotracheitis vaccine. One of the buildings at the Animal Disease Station is used exclusively for this purpose.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	Henry A. Wallace.
Under Secretary	M. L. Wilson.
Assistant Secretary	Harry L. Brown.
Director of Information	M. S. Eisenhower.
Director of Extension Work	C. W. Warburton.
Director of Finance	W. A. Jump.
Director of Personnel	Roy F. Hendrickson.
Director of Research	James T. Jardine.
Director of Marketing and Regulatory Work	A. G. Black.
Solicitor	Mastin G. White.
Land Use Coordinator	M. S. Eisenhower.
Office of Plant and Operations	Arthur B. Thatcher, *Chief.*
Office of C. C. C. Activities	Fred W. Morrell, *Chief.*
Office of Experiment Stations	James T. Jardine, *Chief.*
Office of Foreign Agricultural Relations	Leslie A. Wheeler, *Director.*
Agricultural Adjustment Administration	R. M. Evans, *Administrator.*
Bureau of Agricultural Chemistry and Engineering.	Henry G. Knight, *Chief.*
Bureau of Agricultural Economics	H. R. Tolley, *Chief.*
Agricultural Marketing Service	C. W. Kitchen, *Chief.*
Bureau of Animal Industry	John R. Mohler, *Chief.*
Commodity Credit Corporation	Carl B. Robbins, *President.*
Commodity Exchange Administration	J. W. T. Duvel, *Chief.*
Bureau of Dairy Industry	O. E. Reed, *Chief.*
Bureau of Entomology and Plant Quarantine	Lee A. Strong, *Chief.*
Farm Security Administration	W. W. Alexander, *Administrator.*
Federal Crop Insurance Corporation	Leroy K. Smith, *Manager.*
Federal Surplus Commodities Corporation	Milo R. Perkins, *President.*
Food and Drug Administration	Walter G. Campbell, *Chief.*
Forest Service	Ferdinand A. Silcox, *Chief.*
Bureau of Home Economics	Louise Stanley, *Chief.*
Library	Claribel R. Barnett, *Librarian.*
Division of Marketing and Marketing Agreements.	Milo R. Perkins, *In Charge.*
Bureau of Plant Industry	E. C. Auchter, *Chief.*
Rural Electrification Administration	Robert B. Craig, *Asst. Admin.*
Soil Conservation Service	H. H. Bennett, *Chief.*
Sugar Division	Joshua Bernhardt, *Chief.*
Weather Bureau	Francis W. Reichelderfer, *Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1939

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 10 cents